CLAIMS

1. A light beam switching and adjustment device comprising:

a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses; and

an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals; which is characterized in that

the light guide substrate and the actuator substrate are aligned and joined so that the first positions of the one or more mirrors are advanced positions with respect to the one or more mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses,

first alignment marks which are used to align the light guide substrate and the actuator substrate are formed on the light guide substrate, and

second alignment marks which are used to align the light guide substrate and the actuator substrate are formed on the actuator substrate.

2. The light beam switching and adjustment device according to Claim 1, which is characterized in that the first and second alignment marks can be observed by means of infrared light.

3. The light beam switching and adjustment device according to Claim 1, which is the first or second invention, which is characterized in that the first alignment marks are formed on the first surface of the light guide substrate,

the second alignment marks are formed on the first surface of the actuator substrate, and

the actuator substrate has characteristics that allow the transmission of infrared light.

4. A light beam switching and adjustment device comprising:

a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output

ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses; and

an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals; in which

the light guide substrate and the actuator substrate are aligned and joined so that the first positions of the one or more mirrors are advanced positions with respect to the one or more mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses; which is characterized in that

the supply of electric power to the actuator substrate is performed directly to the actuator substrate from the outside.

5. A light beam switching and adjustment device comprising:

a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output

ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses; and

an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals; in which

the light guide substrate and the actuator substrate are aligned and joined so that the first positions of the one or more mirrors are advanced positions with respect to the one or more mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses; which is characterized in that

the device comprises a relay substrate which is used to relay electrical connections with respect to the actuator substrate,

the relay substrate is joined to the other surface of the actuator substrate so that a portion of this relay substrate protrudes from the actuator substrate, and

the relay substrate does not cover the regions on this other surface of the actuator substrate corresponding to the second alignment marks.

6. The light beam switching and adjustment device according to Claim 5, which is characterized in that a plurality of first pads used for electrical connections are formed on the first surface of the actuator substrate,

a plurality of second pads used for electrical connections are formed on the surface of the relay substrate located on the side of the actuator substrate in the portion of the relay substrate that protrudes from the actuator substrate,

the plurality of first pads and plurality of second pads are respectively electrically connected to each other by bonding wires,

a plurality of third pads used for electrical connections, each of which is electrically connected to one of the plurality of second pads, are formed on the relay substrate,

a plurality of conductive parts which are respectively electrically connected to some of the second pads among the plurality of second pads are formed on the relay substrate, and

the mutual disposition pitch of at least portions of the plurality of conductive parts is wider than the disposition pitch of the plurality of second pads and the disposition pitch of the plurality of third pads.

7. The light beam switching and adjustment device according to Claim 6, which is characterized in that the plurality of conductive parts are formed on the surface of the relay substrate located on the side of the actuator substrate in the protruding portion of the relay substrate, and

the plurality of third pads are formed on the surface of the relay substrate located on the opposite side from the actuator substrate.

8. The light beam switching and adjustment device according to Claim 6, which is characterized in that the device comprises a substrate which has a plurality of lead terminals used for external connections, and

the plurality of third pads and plurality of lead terminals used for external connections are respectively electrically connected to each other by bonding wires.

9. A light beam switching and adjustment device comprising:

a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses; and

an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals; in which

the light guide substrate and the actuator substrate are aligned and joined so that the first positions of the one or more mirrors are advanced positions with respect to the one or more mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses; which is characterized in that

the actuator substrate comprises a plurality of feed terminals used for the electrical driving of the actuators, and one or more terminals of a first type used to perform feeding for the purpose of individually driving the actuators, and one or more terminals of a second type used to perform feeding for the purpose of collectively driving all of the actuators so that all of the one or more mirrors are positioned in the second positions, are included in the plurality of feed terminals.

10. The light beam switching and adjustment device according to Claim 9, which is characterized in that a driving circuit which drives the one or more actuators so that when signals that are used to cause respective desired optical switching operations are supplied to the terminals of the first type, these optical switching operations are performed, and so that when specified signals are supplied to the terminals of the second type, all of the one or more mirrors are positioned in the second positions, is mounted on the actuator substrate.

11. The light beam switching and adjustment device according to Claim 9, which is characterized in that at least one concavo-convex portion is provided in each

mirror, and the insertion depth of the mirrors in the mirror receiving recesses can be observed by using these concavo-convex portions as a focusing reference for the microscopic observation.

12. The light beam switching and adjustment device according to any one of Claims 1 through 11, which is characterized in that the light guide substrate and the actuator substrate are joined with a spacer interposed so that the second positions of the one or more mirrors are positions in which the mirrors are completely retracted from the one or more mirror receiving recesses.

13. The light beam switching and adjustment device according to Claim 12, which is characterized in that the spacer is disposed so that this spacer surrounds the region in which the one or more mirrors are distributed on the actuator substrate.

14. The light beam switching and adjustment device according to Claim 13, which is characterized in that the space between the light guide substrate and actuator substrate is filled with a refractive index adjusting liquid which has a refractive index that is substantially the same as the refractive index of the core layers of the light guides so that this liquid enters the mirror receiving recesses, and

the spacer forms a part of a sealing structure that seals the refractive index adjusting liquid.

15. A light beam switching and adjustment device comprising:

a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses;

an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals; and

a relay substrate which is used to relay electrical connections to the actuator substrate; which is characterized in that

the light guide substrate and the actuator substrate are aligned and joined so that the first positions of the one or more mirrors are advanced positions with respect to the one or more mirror receiving recesses, and so that the second

positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses, and

the relay substrate is joined to the other surface of the actuator substrate so that a portion of this relay substrate protrudes from the actuator substrate.

16. The light beam switching and adjustment device according to Claim 15, which is characterized in that a plurality of first pads used for electrical connections are formed on the first surface of the actuator substrate,

a plurality of second pads used for electrical connections are formed on the surface of the relay substrate located on the side of the actuator substrate in the portion of the relay substrate that protrudes from the actuator substrate,

the plurality of first pads and plurality of second pads are respectively electrically connected to each other by bonding wires, and

a plurality of third pads used for electrical connections, each of which is electrically connected to one of the plurality of second pads, are formed on the relay substrate.

17. The light beam switching and adjustment device according to Claim 15 or Claim 16, which is characterized in that the device comprises a substrate which has a plurality of lead terminals used for external connections, and

the plurality of third pads and plurality of lead terminals used for external connections are respectively electrically connected to each other by bonding wires.

18. The light beam switching and adjustment device according to Claim 16, which is characterized in that a plurality of conductive parts which are respectively electrically connected to some of the second pads among the plurality of second pads are formed on the relay substrate, and

the mutual disposition pitch of at least portions of the plurality of conductive parts is wider than the disposition pitch of the plurality of second pads and the disposition pitch of the plurality of third pads.

19. The light beam switching and adjustment device according to Claim 18, which is characterized in that the plurality of conductive parts are formed on the surface of the relay substrate located on the side of the actuator substrate in the protruding portion of the relay substrate, and

the plurality of third pads are formed on the surface of the relay substrate located on the opposite side from the actuator substrate.

20. The light beam switching and adjustment device according to Claim 18, which is characterized in that all of the one or more mirrors are positioned in the second positions when specified signals are respectively supplied to the plurality of conductive parts.

21. The light beam switching and adjustment device according to Claim 18, which is characterized in that a driving circuit which drives the one or more actuators so that when signals that are used to cause respective desired optical switching operations are supplied to the plurality of third pads, these optical switching operations are performed, and so that when specified signals are respectively supplied to the plurality of conductive parts, all of the one or more mirrors are positioned in the second positions, is mounted on the actuator substrate.

22. A light beam switching and adjustment device comprising:

a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses; and

an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals; which is characterized in that

the light guide substrate and the actuator substrate are aligned and joined so that the first positions of the one or more mirrors are advanced positions with respect to the one or more mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses, and

the light guide substrate and the actuator substrate are joined with a spacer interposed so that the second positions of the one or more mirrors are positions in which the mirrors are completely retracted from the one or more mirror receiving recesses.

23. The light beam switching and adjustment device according to Claim 22, which is characterized in that the spacer is disposed so that this spacer surrounds the region in which the one or more mirrors are distributed on the actuator substrate.

24. The light beam switching and adjustment device according to Claim 23, which is characterized in that the space between the light guide substrate and actuator substrate is filled with a refractive index adjusting liquid which has a refractive index that is substantially the same as the refractive index of the core layers of the light guides so that this liquid enters the mirror receiving recesses, and

the spacer forms a part of a sealing structure that seals the refractive index adjusting liquid.

25. A method for manufacturing a light beam switching and adjustment device comprising:

a step of preparing a light guide substrate [i] which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses, and [ii] on which first alignment marks are formed;

a step of preparing an actuator substrate [i] which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals, and [ii] on which second alignment marks are formed; and

a step of aligning and joining the light guide substrate and the actuator substrate using the first and second alignment marks so that the first positions of the one or more mirrors are advanced positions with respect to the one or more

mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses.

26. A method for manufacturing a light beam switching and adjustment device comprising:

a step of preparing a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses;

a step of preparing an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals;

a step of preparing a spacer that is joined between the light guide substrate and the actuator substrate;

a spacer joining step in which the spacer is joined to either the light guide substrate or the actuator substrate; and

a step which is performed following the spacer joining step, and in which the light guide substrate and actuator substrate are aligned, and the spacer is joined to the other of the two substrates, i.e., either the light guide substrate or actuator substrate, so that the first positions of the one or more mirrors are advanced positions with respect to the one or more mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses; which is characterized in that

when the spacer is joined between the light guide substrate and actuator substrate, the second positions of the one or more mirrors are positions in which the mirrors are completely retracted from the one or more mirror receiving recesses.

27. The method for manufacturing a light beam switching and adjustment device according to Claim 26, which is characterized in that first alignment marks are formed on the light guide substrate, second alignment marks are formed on the actuator substrate, and

the alignment of the light guide substrate and the actuator substrate is performed utilizing the first and second alignment marks.

28. The method for manufacturing a light beam switching and adjustment device according to any one of Claims 25 through 27, which is characterized in that the actuators are constructed so that when absolutely no signals are supplied, the mirrors supported on these actuators return to specified positions that are farther

from the actuator substrate on the first surface of this substrate than the second positions, and

when the light guide substrate and the actuator substrate are aligned, specified signals are applied to the actuator substrate, so that all of the one or more mirrors are positioned in the second positions.

29. A method for manufacturing a light beam switching and adjustment device comprising:

a step of preparing a light guide substrate which has one or more input ports, a plurality of output ports, one or more mirror receiving recesses that are formed in one surface of the light guide substrate, and light guides that conduct the light that is input into the one or more input ports to selected output ports among the plurality of output ports in accordance with the advance and retraction of the one or more mirrors with respect to the one or more mirror receiving recesses;

a step of preparing an actuator substrate which has the one or more mirrors and one or more actuators which are disposed in positions corresponding to the one or more mirrors so that these actuators support the corresponding mirrors, and which position these corresponding mirrors on the side of one surface of the actuator substrate in a first position that is relatively far from this surface or in a second position that is relatively close to this surface, in accordance with signals; and

a step of aligning and joining the light guide substrate and the actuator substrate so that the first positions of the one or more mirrors are advanced

positions with respect to the one or more mirror receiving recesses, and so that the second positions of the one or more mirrors are retracted positions with respect to the one or more mirror receiving recesses; which is characterized in that

the actuators are constructed so that when absolutely no signals are supplied, the mirrors supported on these actuators return to specified positions that are farther from the actuator substrate on the first surface of this substrate than the second positions, and

when the light guide substrate and the actuator substrate are aligned, specified signals are applied to the actuator substrate, so that all of the one or more mirrors are positioned in the second positions.

30. The method for manufacturing a light beam switching and adjustment device according to Claim 28, which is characterized in that signals are supplied to the actuator substrate so that all of the one or more mirrors gradually return to the specified positions described above following the completion of the alignment between the light guide substrate and the actuator substrate.

31. The method for manufacturing a light beam switching and adjustment device according to Claim 29, which is characterized in that signals are supplied to the actuator substrate so that all of the one or more mirrors gradually return to the specified positions described above following the completion of the alignment between the light guide substrate and the actuator substrate.

32. A light beam switching and adjustment device used for the switching of the light paths of light beams or adjustment of the amount of transmitted light of light beams that are propagated through light guides by inserting and removing insertion plates into and from slits formed in these light guides, which is characterized in that the light guides and slits are disposed on a first substrate, the insertion plates are held by insertion plate driving means disposed on a second substrate, the first and second substrates are disposed so that the insertion plates can be inserted into and removed from the slits, a first region of the first substrate which contains the slits and a second region of the second substrate which is provided with the insertion plates are constructed so that these regions can transmit light of a specified wavelength, this light of a specified wavelength is caused to be incident from either the first region or second region, and the transmitted light is emitted from either the second region or first region, so that the insertion positions of the insertion plates inside the slits can be observed by microscopic observation.

33. A light beam switching and adjustment device used for the switching of the light paths of light beams or adjustment of the amount of transmitted light of light beams that are propagated through light guides by inserting and removing insertion plates into and from slits formed in these light guides, which is characterized in that the light guides and slits are disposed on a first substrate, the

insertion plates are held by insertion plate driving means disposed on a second substrate, the first and second substrates are disposed so that the insertion plates can be inserted into and removed from the slits, either a first region of the first substrate which contains the slits or a second region of the second substrate which is provided with the insertion plates is constructed so that this region can transmit light of a specified wavelength, this light of a specified wavelength is caused to be incident from either the first region or second region, and the reflected light is emitted from the first region or second region, so that the insertion positions of the insertion plates inside the slits can be observed by microscopic observation.

34. The light beam switching and adjustment device according to Claim 32 or Claim 33, which is characterized in that at least one concavo-convex portion is provided in each insertion plate, and the insertion depth of the insertion plates in the slits can be observed by using these concavo-convex portions as a focusing reference for the microscopic observation.